5p

X63-10440
Code 2d

NASA TT F-8238

N71-71404
(ACCESSION NUMBER)
5
(PAGES)
(NASA CR OR TMX OR AD NUMBER)
(THRU)
None
(CODE)
(CATEGORY)
FACILITY FORM 602

FORMATION OF FRAUNHOFER LINES IN THE PRESENCE

OF A MAGNETIC FIELD

by M. Raymond Michard

AVAILABLE TO U.S. GOVERNMENT AGENCIES
AND U.S. GOVERNMENT CONTRACTS ONLY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON June 1962

DRAFT TRANSLATION NASA TT F-8238

JUN 1 1 1962

FORMATION OF FRAUNHOFER LINES IN THE PRESENCE OF A MAGNETIC FIELD

(Formation des raies de Fraunhofer en présence d'un champ magnétique)

(FRANCE)

Comptes-Rendus de
l'Académie des Sciences
T. 253, pp. 2857-2858
Paris, Déc. 1961.

Note of M. Raymond Michard
Presented by
M. André Danjon

10440

ABSTRACT

The transfer equations established by W. Unno to describe the formation of a line in the atmosphere in the presence of a uniform magnetic field are resolved in the Shuster-Schwartzshield approximation. This solution is compared to that obtained in the Milne-Eddington approximation.

COVER-TO-COVER TRANSLATION

The system of transfer equations describing the variation of Strokes parameters as a function of λ in the formation of a line in the presence of a uniform field has been obtained by W. Unno. (ref. [1]). The solution of that system allows to obtain the emergent intensity for the three independent parameters — I, Q, V, and thus the profile of the line for any observation conditions. The application of these equations is necessary, strictly speaking, to derive informations on the magnetic field of a single, complete or partial observation of the Zeeman triplet.

../..

The transfer equations are the following :

$$\left\{\begin{aligned} \cos\theta \frac{dI}{dz} &= (\varkappa_C + \varkappa_I)I + \varkappa_Q Q + \varkappa_V V - \varkappa_C B - \varkappa_I S, \\ \cos\theta \frac{dQ}{dz} &= \varkappa_Q I + (\varkappa_C + \varkappa_I) Q - \varkappa_Q S, \\ \cos\theta \frac{dV}{dz} &= \varkappa_V I + (\varkappa_C + \varkappa_I) V - \varkappa_V S; \end{aligned}\right\} \quad (1)$$

where θ is the emergence angle ; z — the height in the atmosphere ; I, Q, W are the Sotkes parameters ; $\varkappa_c$ — the absorption coefficient in the continuum ; S, B - are the source-functions, respectively in the line and in the continuum

$$\left\{\begin{aligned} \varkappa_I &= \frac{\varkappa_p}{2}\sin^2\psi + \frac{\varkappa_l + \varkappa_r}{4}(1 + \cos^2\psi), \\ \varkappa_Q &= \left(\frac{\varkappa_p}{2} - \frac{\varkappa_l + \varkappa_r}{4}\right)\sin^2\psi, \\ \varkappa_V &= \frac{\varkappa_r - \varkappa_l}{2}\cos\psi; \end{aligned}\right\} \quad (2)$$

ψ being the angle between the field and the aiming line ; $\varkappa_p$ is the absorption coefficient for the oscillator π of the Lorentz theory, $\varkappa_l$ and $\varkappa_r$ — those of the oscillators - $\pm\sigma$ (case of the Zeeman triplet). These absorption coefficients are identical to that of the line in the absence of a field, and deflected by $\pm\Delta\lambda(H)$ for the oscillators $\pm\sigma$.

The analytical solution of equations (1) and (2) has been given by Unno for the Milne-Eddington approximation : $\varkappa_p$ $\varkappa_l$, $\varkappa_r$ independent from z ; $S \equiv B$; B being a linear function of the optical depth in the continuum τ_c. The obtained solution is simple, but has the inconvenience of being based upon the hypothesis that the selective absorption coefficient to continuous absorption coefficient ratio is independent from the depth. This approximation is physically very incorrect for the neutral atom lines in the solar atmosphere.

Another classical approximation (Schuster-Schwartzshield) consists in assuming that all the absorbing atoms in the line are concentrated into a superficial layer where $\varkappa_c = 0$; below that "inverting layer" $\varkappa_{p,l,r} = 0$. With such a two-layer atmosphere model the solution of equations (1) and (2) may also be obtained in an analytical form. We shall present it below in terms of d e p r e s s i o n of the continuum $r_I = (I_0 - I)/I_0$, etc..

Assuming the selective absorption coefficients $\varkappa_{p,l,r}$ independent from z in the "inverting" layer of total thickness Z, we introduce the optical thicknesses $\tau_p = \varkappa_p Z$, $\tau_l = \varkappa_l Z$, $\tau_r = \varkappa_r Z$, and the optical thicknesses whose definition is given by the equations (2). Let us moreover postulate that $\tau_{QV} = \sqrt{\tau_Q^2 + \tau_V^2}$, and $\cos\theta = \mu$. The solution of (1) then becomes :

$$\left.\begin{cases} r_I = \dfrac{I_0 - S}{I_0}\left(1 - e^{-\frac{\tau_I}{\mu}}\dfrac{e^{\frac{\tau_{QV}}{\mu}} + e^{-\frac{\tau_{QV}}{\mu}}}{2}\right), \\ r_Q = \dfrac{I_0 - S}{I_0}\dfrac{\tau_Q}{\tau_{QV}}e^{-\frac{\tau_I}{\mu}}\dfrac{e^{\frac{\tau_{QV}}{\mu}} - e^{-\frac{\tau_{QV}}{\mu}}}{2}, \\ r_V = \dfrac{\tau_V}{\tau_Q} r_Q ; \end{cases}\right\} \quad (3)$$

I_0 being the incident intensity under the "inverting" layer and a function of $\cos\theta$; S is the source-function in the "inverting" layer, assumed constant.

The obtained solutions in the two extreme approximations of Milne-Eddington and Schuster-Schwartzschield have different characteristics. First the center-edge profile variation is deeply modified ; in the Milne-Eddington case the depressions r have the form $f_1(\cos\theta)\, f_2(\lambda)$, — and in the case Schuster-Schwarzshield — $f_3(\cos\theta)\, f_4(\cos\theta, \lambda)$. - Limiting ourselves to the center of the disk ($\cos\theta = 1$) let us take a typical line, and let us choose the parameters describing that line so as its profile be practically the same as in the absence of a field in the two approximations : The computations by means of the Unno formulae and formula (3) show that this identity of both representations is not preserved in the presence of a magnetic field (except when this field is longitudinal).

The determination of size and direction parameters of the field starting from profile measurements in polarized light depends sensibly on the model utilized to describe the transfer in the line.

REFERENCE

1. WASABURO UNNO, Publ. Astr. Soc. Japan, 8, p.108, 1956.

(Paris-Meudon Observatory)

***** END *****

Translated by ANDRÉ L. BRICHANT
for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
9 June 1962.